CHEM 2110 **TEST 4** **10 MAY, 2012**

Chemistry for Medicine

Name: MODEL ANSWERS **ID Number:** _____

Time: 1½ hours

Useful constants: 1 Å = 10^{-8} cm

O=O (double bond) ~1.20 Å

O–O (single bond) ~1.48 Å

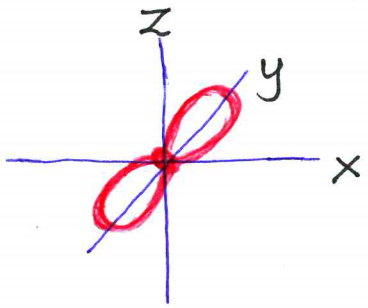
1 H 1.008																	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La* 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226	89 Ac† (227)															

QUESTION	SCORE	MAXIMUM MARKS
TOTAL		95

(a) Sketch and **describe** the following orbitals:

(i) The atomic orbital with the quantum numbers $n = 3$, $\ell = 1$, $m_\ell = -1$

The atomic orbital is $3p_y$



The $3p_y$ atomic orbital has two lobes which lie on the y-axis with a nucleus at the centre. This orbital is in the third shell. Therefore it has one radial node $(n-\ell-1)$

(ii) The hybrid orbital of carbon in C_2H_2 gas.

H—C≡C—H each carbon atom is sp hybridised. The two sp hybrid orbitals lie on the z-axis

sp hybrid orbital. The sp hybrid orbital is a mixture of both s and p orbitals.

(b) What is ψ_{n,ℓ,m_ℓ} and where does it come from?

ψ_{n,ℓ,m_ℓ} represents the wavefunction of a specific atomic orbital. It is derived from the Schrödinger equation

(c) Arrange the following atomic orbitals of the hydrogen atom in order of increasing energy (from lowest to highest):

4f 6s 3p 5f 3d 4s 2p

$2p < 3p = 3d < 4s = 4f < 5f < 6s$

This arrangement is according to what principle, law or rule?

Aufbau principle

(d) What is the set of quantum numbers for the valence electron of potassium?

$[Ar]4s^1$: $n=4, \ell=0, m_\ell=0, m_s=+\frac{1}{2}$

(e) (i) What do we mean by the term *shape of a molecule*? (Do not draw any shape).

The three-dimensional structure that shows the orientation of the atoms in space

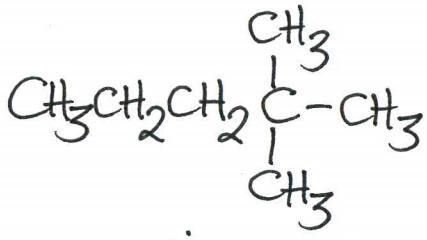
(ii) List three properties of matter that are influenced (affected) by the shape of a molecule.

polarity

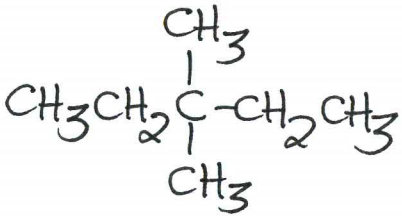
reactivity

intermolecular forces

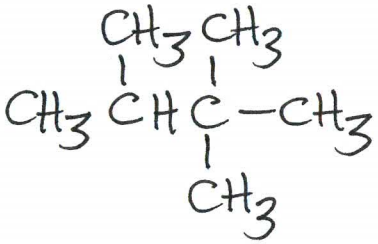
(iii) Draw and name the isomers of **heptane** with a quaternary carbon atom.



2,2-dimethylpentane



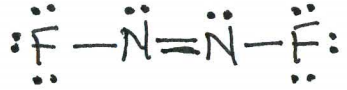
3,3-dimethylpentane

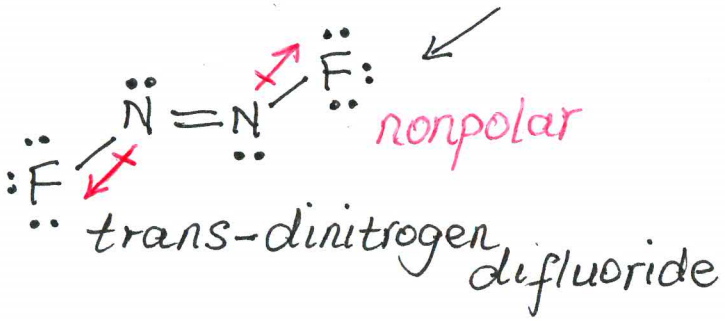


2,2,3-trimethylbutane

(iv) Draw and name the isomers of N_2F_2 ~~and name them~~. Show if they are polar or nonpolar.

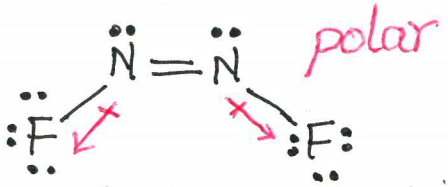
$Ve^- = 2(5)+2(7) = 24e^- = 12e^-$ prs





nonpolar

trans-dinitrogen difluoride



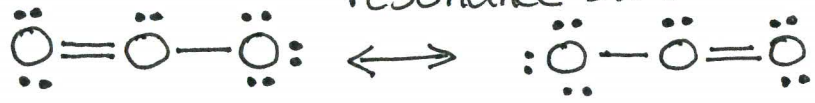
polar

cis-dinitrogen difluoride

(f) The bonds in ozone are identical and have a length of 128 pm. The angle is ~117°.
Discuss the structure of ozone.

O_3 $v\bar{e} = 3(6) = 18\bar{e} = 9\bar{e}prs$

resonance structures



resonance hybrid structure

VSEPR formula $= AB_2E$

AB_2E
$\Rightarrow$ trigonal planar orbital shape

$\Rightarrow$

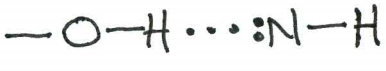
angular molecular shape.

Since O_3 exists as a resonance hybrid, its bonds are intermediate between O—O (1.48 Å) and O=O (1.20 Å).
The angle is smaller than 120° because of the stronger lone-pair–bond pair repulsions compared to bond-pair–bond pair repulsion.

(g) Hydrogen bonding is one of three types of noncovalent intermolecular forces;
the other two are dipole–dipole forces and London dispersion forces

What is the specific definition of a hydrogen bond? Give an example.

A weak electrostatic attractive force between a hydrogen atom bonded to a highly electronegative atom and the lone pair(s) of electrons on a highly electronegative another atom

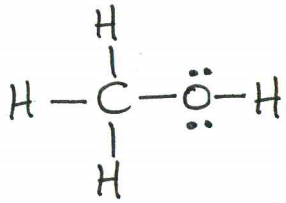
e.g. 

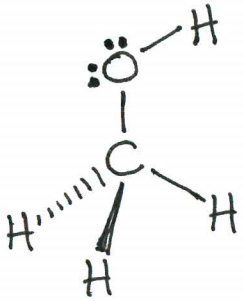
Give three physical properties of matter affected by hydrogen bonding:

solubility
boiling point
protein folding

(h) Draw the molecular shapes of the following substances:

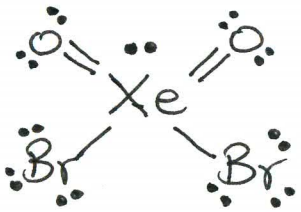
(i) Methanol, CH_3OH $Ve^- = 4 + 4(1) + 6 = 14e^- = 7e^-prs$

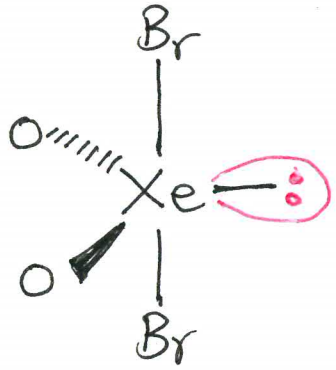




(ii) Nitrous acid, HNO_2 $Ve^- = 1 + 5 + 2(6) = 18e^-$
$= 9e^-prs$

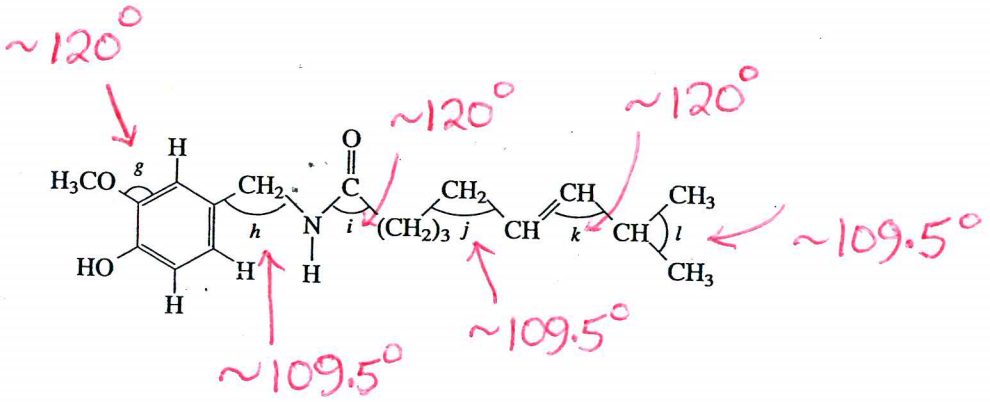
(iii) XeO_2Br_2 $Ve^- = 8 + 2(6) + 2(7) = 34e^- = 17e^-prs$





(iv) The peroxide ion, O_2^{2-} $Ve^- = 2(6) + 2$
$= 14e^- = 7e^-prs$

(i) Give the angles around the atoms indicated by the letters of the alphabet:



(j) Complete the following statements

A Lewis structure is drawn for a molecule or polyatomic ion whereas a Lewis dot symbol is drawn for a monatomic ion or a neutral atom.

The best Lewis structure must have the smallest formal charges

Lone pairs of electrons are also known as nonbonding pairs of electrons

According to Hund's rule, an atom in the ground state must have a maximum number of unpaired electrons in a given set of degenerate orbitals.

A diamagnetic substance is repelled by a magnetic field

The highest principal quantum number in an atom is $n = \infty$

The number of valence electrons in a triple bond is six

Chemical bonds are classified as ionic, polar, and nonpolar according to electronegativity between the two atom chemically bonded together. They are also classified as multiple or single according to their bond order.

The angles around the central atom in a square pyramidal structure are 90° and 180° and the total number of these angles is 10

Iron(III) has an electron configuration of $[Ar]\,3d^5$ with 5 unpaired electrons in the subshell with ℓ = 2

The Bohr radius is 0.5292 Å.

In terms of electrons, an atom of aluminum has one unpaired electron and a molecule of ammonia has one lone pair of electrons

F is the most electronegative element in the periodic table

Transition metals are found in the d-block whereas main-group metals are found in the s- and p-blocks

The general electron configuration of the valence electrons of Group 14 metals is ns^2np^2; therefore the oxidation states of these metals are +2 and +4 in their ionic compounds.